2.4 Looking at leaves

Lesson overview

Learning objectives

- Relate the size of a leaf to the availability of light.
- Relate the function of the leaf to its structure and the types of cell.
- Evaluate the structure of a cell related to its function.

Learning outcomes

- Name the common features of leaves that are adaptations to photosynthesis; explain how the size of leaves relates to the availability of light. [O1]
- Explain the functions of the different cells in a leaf; identify the different cells found in the leaf. [O2]
- Critically evaluate the structure of different cells related to their function. [O3]

Skills development

- Thinking scientifically: develop explanations
- Working scientifically: record evidence
- Learner development: communicate effectively

Resources needed variety of leaves; microscopes; slides of transverse sections of leaves; equipment and materials for class practical as detailed in the Technician's notes; Worksheet 2.2.4; Practical sheet 2.2.4; Technician's notes 2.2.4

Digital resources Quick starter; Slideshow: A detailed look at the different components of a leaf; Interactive activity: Match the adaptations of the leaf to its function; Hangman: Key vocabulary game

Common misconceptions Cells are two-dimensional. All cells are the same shape. Cells are like particles or atoms.

Key vocabulary cuticle, epidermis, palisade cell, spongy cell

Teaching and learning

Engage

- Give each group a selection of leaves of different sizes and shapes. Ask the students to **discuss** what features all leaves have in common and why these features might be important. Take feedback, one point from each group at a time, and discuss with the class. [O1]
- Alternatively ask the students to work in pairs to **construct** a large annotated diagram of a leaf to show how it is designed to photosynthesise. Discuss why leaves are green – they contain chlorophyll, which absorbs light energy needed for photosynthesis. [O1]

Challenge and develop

- The students use a microscope to **observe** prepared slides of transverse sections of a leaf. They **draw** and **identify** the layers of cells. Ask the students to **compare** the leaf cells close to the darker upper surface with other cells. Make sure they identify that there are more chloroplasts near the upper surface. [O1]

Explain

- The students work in pairs following the instructions on Practical sheet 2.2.4 to extract chlorophyll from leaves and separate the pigments using chromatography. Discuss why the chlorophyll contains more than one pigment (simply to absorb more light at this stage) and how being able to absorb more light will be an advantage to the plant. [O1]
- Ask the students to use the Student Book and the internet to **research** and **explain** the functions of the different cell types. Take feedback. [O2]

Consolidate and apply

- The students use Worksheet 2.2.4 to **complete** a table explaining the functions of the different cell types. [O2]
- Ask the students to **discuss** and **explain** why water-lily leaves float on the surface of water. Take feedback. [O2]
- The students work in pairs to complete task 2 of Worksheet 2.2.4 and **identify** the adaptations of each cell type that help it to carry out its functions. [O3]

Extend

- Ask students able to progress further to work in pairs to **evaluate** the structure of each cell type related to its function (task 3 of Worksheet 2.2.4). [O3]

Plenary suggestions

An ideal leaf Ask the students to **draw** and **label** an 'ideal leaf' incorporating as many of the adaptations studied in this lesson as possible. [O1, 2&3]

Ask me a question Alternatively the students work in groups to **develop questions** starting 'How, where, when, why and what' on the topic, providing answers as well. Students **peer-assess** another group's work. Take feedback. [O1, 2&3]

Answers to Student Book questions

1. leaves are thin, broad and flat; they are green and contain chlorophyll; they have a network of veins
2. they are thin to allow fast gas exchange by diffusion; broad and flat to give a large surface area to absorb light; the chlorophyll absorbs light energy; the veins transport water, sugar and minerals
3. palisade cells
4. plants on the forest floor have very large leaves; leaves on the trees are much smaller
5. Plants on the forest floor receive much less light than those on the tall trees; the larger surface means they can absorb more light to photosynthesise.
6. Larger leaves contain more chlorophyll; to absorb all the light that reaches them.
7. Carbon dioxide moves into the leaf in daytime; and oxygen moves out; by diffusion.
8. see answers to Worksheet 2.2.4 below ('Adaptations' column)
9. see answers to Worksheet 2.2.4 below (final column)

Answers to Worksheet 2.2.4

Name of cell/ layer in the leaf	Function of the cell/layer	Adaptations of the cell	How do these adaptations allow the cell to carry out its functions?
Cuticle	Protects leaf from water loss	Made of wax	It is waterproof
Epidermis	Allows light to reach palisade cells	Thin and transparent	Light is able to pass through
Palisade cells	To absorb light	At the top of the leaf Cells are long and narrow Contain many chloroplasts Chloroplasts are concentrated at the top of the cell	So light does not have far to travel So more cells are at the top of the leaf To absorb the light energy To absorb as much light as possible
Spongy cells	To absorb remaining light To allow gases to pass in/out of the leaf	Contain chloroplasts Large air spaces between the cells	To absorb all the remaining light To allow gas exchange in and out of the leaf

Worksheet 2.2.4 Looking at leaves

1 Leaf cells >

Think about the different types of cells and layers in a leaf. Your task is to find out why these cells are different.

a) Use the Student Book and the internet to research the functions of the different types of cells in a leaf.

b) In a table like the one below, explain the functions of the different cells/layers found in the leaf.

Name of cell/ layer in the leaf	**Function of the cell/layer**
Cuticle	

2 Adaptations >>

The different cells/layers in the leaf look different from each other. They have adaptations that help them carry out their functions.

a) Work with a partner to identify the adaptations of the different cells.

b) Add a column to your table from task 1 to detail the adaptations of different cell types.

Name of cell/ layer in the leaf	**Function of the cell/layer**	**Adaptations of the cell**
Cuticle		

3 Cell structure >>>

Think about the adaptations of each different cell type.

a) Work with a partner and discuss how these adaptations help the different cell types to carry out their functions in the leaf.

b) Add a final column to your table to explain how the adaptations allow the cells to carry out their function.

Name of cell/ layer in the leaf	**Function of the cell/layer**	**Adaptations of the cell**	**How do these adaptations allow the cell to carry out its functions?**
Cuticle			

Practical 2.2.4 Extracting chlorophyll

In this practical you will follow the instructions to extract chlorophyll and then separate the pigments.

Apparatus

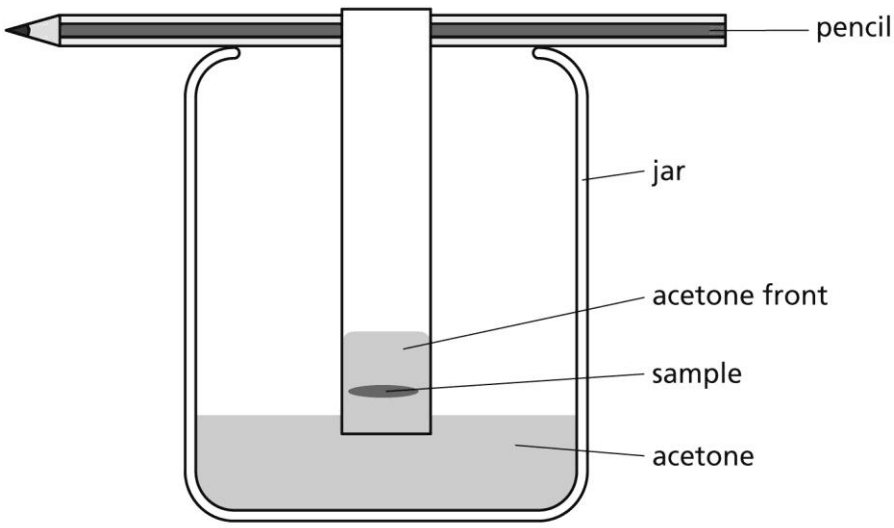
You will need:

- leaves
- pestle and mortar
- acetone
- 250 cm^3 beaker
- chromatography paper
- filter funnel and filter paper
- capillary tubing or dropper
- pencil

Instructions

Work in a group of three:

- **Person 1**: Collect a leaf, cut it up and use a pestle and mortar with 10 cm^3 of acetone to grind it up.
- **Person 2**: Measure out 1 cm^3 of acetone in a 250 cm^3 beaker. Take a piece of chromatography paper and draw a line in pencil 2 cm up from the bottom.
- **Person 3**: Set up a filter funnel and filter paper to collect the filtrate from the ground-up leaf and acetone. Use a capillary tube to paint a green dot of filtrate on the pencil line and hang the paper in the acetone using a pencil.



Questions

1. How many pigments are there in the chlorophyll?
2. What colours are they?
3. Do you think red seaweed would produce the same chromatogram?

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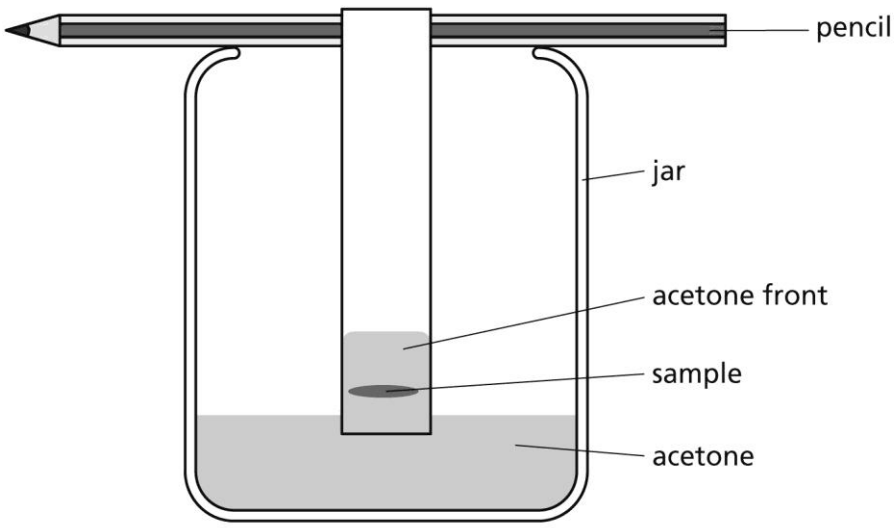


Questions

1. How many pigments are there in the chlorophyll?
2. What colours are they?
3. Do you think red seaweed would produce the same chromatogram?

4.12 Investigating the effectiveness of antacids

Lesson overview

Learning objectives

- Design an investigation to compare the effectiveness of indigestion remedies.
- Analyse data to identify a suitable indigestion remedy.

Learning outcomes

- Describe indigestion remedies and the way that they work. [O1]
- Design a suitable investigation to compare indigestion remedies fairly. [O2]
- Analyse data to make a justified decision about the best remedy. [O3]

Skills development

- Thinking scientifically: analyse data
- Working scientifically: design investigations
- Learner development: collaborate effectively

Resources needed equipment and materials as detailed in the Technician's notes; Worksheet 2.4.12; Practical sheet 2.4.12; Technician's notes 2.4.12

Digital resources Quick starter; Interactive activity: Place the steps of the antacid experiment into the correct order

Common misconceptions Antacids neutralise stomach acid to form a neutral solution (pH 7).

Key vocabulary indigestion, heartburn, antacid, base, neutralisation

Teaching and learning

Engage

- Show some adverts for indigestion remedies and, if possible, video clips. [O1]
- Ask the students to work in pairs to **discuss** and **write down** anything that they know about indigestion or its remedies. [O1]
- If necessary, remind them that we always have acid in our stomach (approximately pH 1–2). If the sphincter at the top of the stomach opens, this acid can move up towards the throat. This causes heartburn or indigestion. Ask the students to **suggest** what indigestion remedies are. Ask them to **suggest** what the reaction between the stomach acid and the remedy is. [O1]

Challenge and develop

- **Group work** Ask the students to work in groups of four to **brainstorm** how they could **investigate** which is the most effective remedy. Encourage students to be as creative as possible at this stage and to **generate** as many ideas as possible. Allow them access to packaging during this activity (or to copies of ingredient and dosage information). [O1&2]
- Ask the groups to **share** some of their ideas across the class. [O1&2]

Explain

- Ask groups of four to split into pairs. The new pairs should **plan** an investigation to find the most effective remedy for indigestion. Encourage students to use the information and **discussion** from the previous activity to help them. Practical sheet 2.4.12 can be used to support planning. [O2]

- Check each group's plan for suitability and safety before allowing them to **carry out** the investigation. You will need to be flexible in terms of equipment needed. It will be useful to set up some beakers of distilled water with universal indicator added, to remind the students what neutral pH looks like. [O2]
- If the students need support, give them some ideas about how to carry out the investigation. For example:
  - Use the recommended dose of remedy and, if it is in tablet form, crush it in a pestle and mortar.
  - Set up two beakers of hydrochloric acid and add universal indicator to each – keep one for comparison and add the remedy to the other.
  - Observe the colour change of the indicator and record this along with any other observations.
  - Repeat with at least one more remedy for comparison.

  You could ask higher-attaining students to use a pH meter to generate data about changes in pH over time.

Consolidate and apply

- Ask students to **analyse** their data to decide which indigestion remedy is the most effective (Practical sheet 2.4.12 supports this analysis). [O3]
- Encourage those students without a full set of results to **collaborate** with another group carrying out the investigation in a similar way. Worksheet 2.4.12 could be used to give practice in interpreting data. [O3]

Extend

- Ask students able to progress further to **evaluate** the investigation, **suggesting** improvements and the next steps.

Plenary suggestions

Adverts The students create an advert to promote the remedy that they have found to be the most effective. Encourage them to **consider** the adverts that were seen at the start of the lesson. Remind them of the need to educate as well as entertain an audience. [O1, 2&3]

Answers to Student Book questions

1. hydrochloric acid; strong (pH 1)
2. digestion of proteins; prevention of the survival of some bacteria
3. a burning sensation in the chest and throat; caused by stomach acid moving up the oesophagus
4. calcium carbonate; magnesium hydroxide
5. an alkali (or base) neutralises the stomach acid; making the solution less acidic
6. increase the pH
7. stomach acid is approximately pH 1–2
8. 'Acid-ease' liquid; it changes the pH from 1 to 6; takes only 3 minutes
9. the time may decrease; because of increased surface area of 'Acid-ban' tablets

Answers to Worksheet 2.4.12

1. C; B; A; D
2. a) saliva is alkaline; helps to neutralise any acid that leaves the stomach
   b) limestone contains calcium carbonate; that neutralises acid
   c) bicarbonate of soda is alkali; so it neutralises acid
   d) this prevents acid from moving up the oesophagus easily
3. a) A pH 4; B pH 6; C pH 5
   b) B; it neutralises the acid to a pH nearest to neutral
   c) C takes longer; but neutralises the acid to pH7; so this could be better
   d) look for sensible suggestions such as cost, availability and taste

Worksheet 2.4.12 Investigating the effectiveness of antacids

1 The cause of heartburn indigestion >

Sequence the statements to explain how heartburn is caused.

A Acid moves up from the stomach and into the oesophagus.

B The muscle leading from the oesophagus to the stomach relaxes and opens.

C As we eat, the stomach produces more acid to help us digest proteins.

D A burning sensation is felt in the throat and chest. This is indigestion or heartburn.

2 Treating heartburn >>

There are many remedies available to treat heartburn. Natural remedies have been around for many years, even before we understood the need to neutralise the stomach acid.

Suggest why each of the following natural remedies helps to ease heartburn:

a) Chewing gum after a meal to increase saliva production

b) Chewing limestone rocks

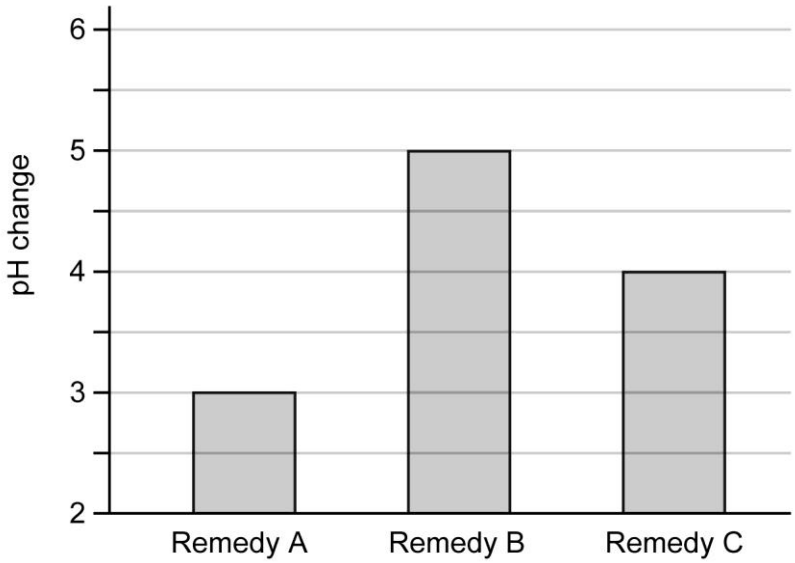
c) Drinking bicarbonate of soda dissolved in water

d) Propping yourself up in bed, rather than lying flat

Worksheet 2.4.12 Investigating the effectiveness of antacids

3 Analysing the effects of antacids >>>

Students compared the pH change caused by heartburn remedies. They added the recommended dose of each to acid at pH 1. They re-measured the pH after 5 minutes.



a) Record the pH of each of the solutions after 5 minutes.

b) Using information in the graph, which remedy is the most effective for heartburn? Explain your answer.

c) Two minutes after the investigation was complete, one of the students measured the pH again. Solutions containing remedies A and B had not changed but the solution containing remedy C was measured at pH 7. Explain how this may change your answer to b).

d) Suggest some other factors that may determine the choice of remedy that is bought.

Practical 2.4.12 Comparing treatments for indigestion

In this practical you will design and carry out an investion to compare the effectiveness of treatments for indigestion.

Identifying variables

1. Identify the **dependent variable** (the one that you will measure).
2. Identify the **independent variable** (the one that you will change).
3. List the variables that you will need to control.

Method

4. Write a method of how you will measure the effectiveness of the antacids.
5. Write a list of apparatus that you will need.
6. Explain how will know which antacid is the most effective.
7. Prepare a results table before you begin the investigation.
8. Check your plan with a teacher before you carry out the investigation.

Results

Record your results. Would it be useful to display the data in a graph?

Analyse results

1. Explain what your results show about which remedy is most effective.
2. Suggest any reasons why this remedy may be more effective. (Tip: look at the ingredients, consider whether the remedy was liquid, powder or tablet.)

Evaluate data and method

3. Consider your results. Do you think that your results were:

   a) accurate

   b) repeatable?
4. Suggest any improvements to your method to improve the quality of the data.

Technician's notes 2.4.12 Investigating the effectiveness of antacids

Be sure to check the latest CLEAPSS safety notes before proceeding.

Introduction

This is a demonstration of examples of packaging from indigestion remedies and a class investigation assessing indigestion remedies.

The following resources may be needed for the class practical, per group

dilute hydrochloric acid (0.01 M)
dose of at least three different antacid remedies (some solid and some liquid if possible)
packaging of the antacids to show dosage
6 × 100 ml beakers
iron filings
mortar and pestle
100 ml measuring cylinder
beaker of distilled water
universal indicator
stopclock
pH meter/colour chart

The remedies should be antacid remedies and not alginates as these do not neutralise acid.
As the students plan their own investigation, the resources required may vary.

6.10 Investigating batteries

Lesson overview

Learning objectives

- Describe the link between chemical energy and electricity.
- Investigate how fruit batteries work.

Learning outcomes

- Describe different types of battery; design an investigation to control key variables. [O1]
- Describe how to make the most effective fruit batteries; analyse and interpret results. [O2]
- Explain how a fruit battery works using ideas about charge. [O3]

Skills development

- Thinking scientifically: analyse data
- Working scientifically: design investigations
- Learner development: ask questions

Resources needed images of early batteries including the first one produced by Volta; (optional, for the plenary) a plan of an investigation of fruit batteries with deliberate mistakes, possibly as a slideshow; graph paper; equipment and materials as detailed in the Technician's notes; Worksheet 2.6.10; Technician's notes 2.6.10

Digital resources Quick starter; Slideshow: Inside batteries: The similarities and differences between types of cell; Interactive activity: Complete the sentences about batteries; Video

Key vocabulary, battery, electron, electric current, voltage

Teaching and learning

Engage

- Show the students images of early batteries including the first produced by Volta (see Figure 2.6.10a in the Student Book). Discuss how a battery works using ideas presented in the second section in the Student Book. Discuss some examples of applications of batteries. [O1]
- **Pairs** Show the students a range of different batteries. Ask them to **write down** as many differences as they can between the different batteries. Take feedback and write the main differences on the whiteboard. Ensure that they understand that the 'power' of a battery is represented by the voltage it has. Explain that the meaning of the term 'voltage' will be examined in a future lesson. [O1]

Challenge and develop

- Show the students at least one example of a fruit battery connected to a voltmeter (see Technician's notes 2.6.10). Tell them that these batteries work using metal electrodes connected by wire. [O1]
- **Group work** Working in pairs, give the students pieces of fruit and a range of metals to test. Ask them to **plan an investigation** to identify how to make the fruit battery with the highest voltage. They should use Worksheet 2.6.10 to guide their planning. [O1&2]
- Discuss the differences between random and systematic errors in the context of this investigation, and the ways that these might be identified and eliminated. [O1&2]

  Higher-attaining students should **define** all values for control variables and **explain** how to collect accurate, reliable data.
- When their plans have been reviewed, ask the students to **carry out** their investigation, **recording** all their results. [O1&2]
- The students should **plot graphs** to display their results. [O2]

Explain

- The students should **explain** the findings of their investigation, using their graphs and results. [O3]
- They could **draw** annotated diagrams of the fruit battery, **explaining** how electrons build up on the plate and how this causes a current to flow in the juice of the fruit. [O3]

Consolidate and apply

- Ask the students to answer the questions in the Student Book. [O1, 2&3]
- They should **consider** why only a small voltage is produced from this setup. They should **compare** their setup with that of Volta and **design** a system to produce more voltage from given fruits and metals. [O3]

Extend

- Students able to progress further could extend their investigation to **find out** which of the variables – for example the metals, the distance between the metals, the depth the metals are inserted into the fruit or the type of fruit – has the most impact on the voltage produced. The students could be given the data from other groups who have investigated these variables and **compare** the results. They should **develop** their own hypothesis first and then use the data to **test** it. [O3]

Plenary suggestions

Spot the mistakes Provide the students with a plan of an investigation into fruit batteries with lots of deliberate mistakes, possibly as a slideshow. Ask them to find and correct the mistakes. [O1, 2&3]

Answers to Student Book questions

1. Chemical energy is being tranferred by electric current and heat; if used for long periods of time, lots of heat is transferred to the surroundings.
2. stored chemical energy → energy transferred by electricity + energy transferred by heating
3. for example:
   - chemical changes occur in the battery
   - electrons move and build up on the negative terminal
   - electrons in the connecting wires move as a result
   - a current flows in the connecting wires
   - energy is transferred by the current to appliances
4. *advantages*: no movement energy or moving parts needed, which can break; a continuous current is produced; smaller batteries can produce more current for the same size of dynamo

   disadvantages: the battery will run out; and will need to be replaced
5. The bigger the difference in reactivities of the metals, the larger the voltage produced.
6. a) Decrease the distance between the metal plates; the charge can be carried more quickly.

   b) Use a fruit with more juice; the bigger the amount of juice, the bigger the flow of charged particles.

Answers to Worksheet 2.6.10

1. a) *Possible variables*: type of metal; type of fruit; distance between metal plates; depth metal plates are inserted into fruit. Any of these many be chosen as an independent variable, with all others as control variables.

   b) For example, if the type of metal is chosen as the independent variable, suitable values would be iron, zinc, copper, magnesium and aluminium.

   c) voltage d) using a voltmeter e) whichever of the variables are not chosen as the independent variable

   f) For example, if the type of metal is the independent variable, suitable control variables would be the distance of the plates (10 cm); the depth of the plates (2 cm), the type of fruit (lemon).

   g) acidic juice from the fruits h) safety glasses would be a good idea
2. a) By making accurate measurements of all control variables; using a mm ruler; using a digital voltmeter to increase the degree of accuracy.

   b) Perform repeats; to see if the investigation is reproducible and repeatable; consistent readings confirms the reliability of the investigation. Produce a suitable graph with the independent variable on the *x*-axis and voltage on the *y*-axis; check the scale to ensure it is suitable.
3. a) Putting the plates at different depths; not accurately putting the plates the same distance apart.

   b) The fact that each fruit is unique and therefore the liquid inside will not be exactly the same as in other fruits; the metal plates may not be brand new and may have some corrosion on them.

   c) For example: make sure the metal plates were thoroughly clean, use a mm ruler to measure distances instead of a cm ruler, ensure the plate had the same surface area, have a large sample size of fruit to ensure reliability.

   d) Appropriate conclusions drawn from the data; the most reactive metal and the least reactive metal plate will produce the greatest voltage.

Worksheet 2.6.10 Investigating batteries

1 What are the variables? >

You are planning an investigation to find out how to make a fruit battery with the highest voltage.
Write down all the possible variables in the investigation.

a) Choose one variable. What is the independent variable in your investigation?

b) What values will you choose?

c) What is the dependent variable?

d) How will you measure it?

e) Which variables will you control?

f) What values will you choose for these?

g) What are the hazards and risks of the investigation?

h) What safety precautions will you take to address these risks and hazards?

2 Accuracy and reliability >>

a) How will you make sure that your results are accurate?

b) How will you make sure that your results are reliable?

3 Evaluate your investigation >>>

a) What are the random errors in your investigation?

b) Identify some systematic errors in the investigation.

c) What could you do to improve your investigation further?

d) What conclusions can you draw from your investigation?

Technician's notes 2.6.10 Investigating batteries

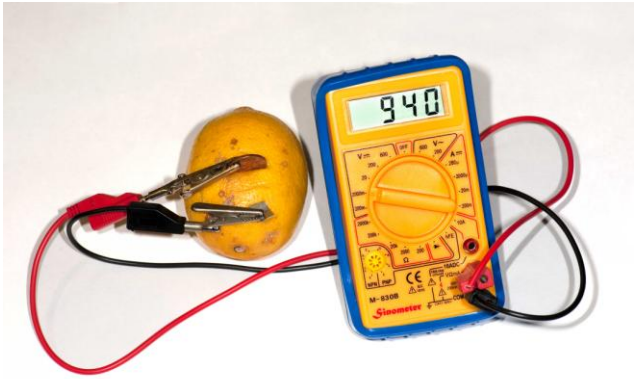
Be sure to check the latest CLEAPSS safety notes before proceeding.

Introduction

First, a display of different types of batteries, including a real fruit battery, will be presented to the students. They will then plan to investigate one chosen factor involved in a making fruit battery and use their plan to identify how to generate the highest voltage.

The following resources are needed for the demonstration of a fruit battery

citrus fruit such as a lemon that has been rolled around to soften it, allowing juices to flow more readily
2 identically-sized metal plates/strips of different metals e.g. zinc and copper
crocodile clips
connecting wires (insulated)
voltmeter
small LED



Set up the fruit battery demonstration as shown in the photograph. If the voltmeter is replaced with a low current LED the light should come on.

The following resources are needed for the class investigation, per group, for the students to choose from (allow for four complete sets)

selection of citrus fruits such as a lemon, lime, orange, potato
selection of metal strips of the same dimensions made from different metals such as copper, zinc, iron, magnesium
crocodile clips
connecting wires (insulated)
voltmeter
small LED

6.19 Checking students' progress

The ‘Checking your progress’ section in the Student Book indicates the key ideas developed in this chapter and shows how students progress to more complex levels. It is provided to support students in:

- identifying those ideas
- developing a sense of their current level of understanding
- developing a sense of what the next steps in their learning are

It is designed either to be used at the end of a chapter to support an overall view of the progress, or alternatively during the teaching of the unit. Students can self assess or peer assess using this as a basis.

It would be helpful if students can be encouraged to provide evidence from their understanding or their notes to support their judgments. In some cases it may be useful to explore the difference in the descriptors for a particular idea so that students can see what makes for a ‘higher outcome’.

It may be useful with some descriptors to provide examples from the specific work done, such as an experiment undertaken or an explanation developed and recorded. If marking and feedback uses similar ideas and phrases this will enable students to relate specific marking to a more general sense of progress.

To make good progress in understanding science students need to focus on these ideas and skills:

Students who are making modest progress will be able to:	**Students who are making good progress will be able to:**	**Students who are making excellent progress will be able to:**
Describe differences between permanent and temporary magnets.	Describe and compare different methods to make permanent magnets.	Use the domain theory to explain how materials become magnetised and demagnetised.
Describe some effects of the Earth's magnetic field.	Describe the geodynamo theory.	Explain evidence for how the Earth's magnetic field works.
Describe how to test the strength of a magnet and an electromagnet.	Design investigations to compare different methods of making magnets and testing the strength of electromagnets.	Use models and analogies to explain the factors affecting the strengths of magnets and electromagnets.
Describe different applications of magnets and electromagnets.	Explain the advantages of using electromagnets.	Compare and contrast the use of magnets and electromagnets in different applications, such as a circuit breaker.
Describe and investigate different types of batteries, including fruit batteries.	Analyse and interpret data to explain how to make the most effective fruit batteries.	Explain how a battery works, using ideas about charge.
Describe what is meant by current, voltage and resistance.	Apply a range of models and analogies to describe current, voltage and resistance.	Evaluate different models and analogies for explaining current, voltage and resistance.
Describe the relationship between current, voltage and resistance in a qualitative way.	Use data to identify a pattern between current, voltage and resistance.	Use data and a mathematical relationship between current, voltage and resistance, to carry out calculations.
Make measurements of current and voltage in series and in parallel circuits.	Use models and simple calculations to explain and compare what happens to the current and voltage in series and parallel circuits.	Use calculations to make predictions about current and voltage in series and parallel circuits.
Describe different domestic uses of series and parallel circuits.	Make comparisons between components in series and parallel circuits.	Explain the advantages of using series or parallel circuits, including the domestic ring main as an example.

